ORGANIZATION OF ALTERNATIVE RADIO COMMUNICATION IN EMERGENCY SITUATIONS

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Abstract: Radio communication, as a traditional form of communication, has been somewhat overshadowed in today's landscape of technological advancements and digital communication. However, in certain shapes and forms, radio communication plays a key role in civil protection services and protection and rescue units during emergencies. This paper will outline the structure of goals and objectives, as well as the organizational framework of radio communication within the local community, specifically focusing on the municipal civil protection headquarters, according to the legal regulations of the Federation of Bosnia and Herzegovina entity. The paper will also examine the structure of the headquarters and the role of the emergency radio network (RMZO) and amateur radio clubs within these units. The purpose of this paper is to determine the significance of amateur radio associations during emergency situations. This research aims to emphasize the importance of effectively organizing and mobilizing both human and technical resources in response to an emergency event that requires the activation of radio communication. This subject gives rise to the central issue examined in this article - methods and means for establishing an emergency communication network in the case that traditional communication systems become inoperable. This article will emphasize the organization set-up, necessary technical resources, and the various methods, types, and objectives for achieving effective communication in specific situations, highlighting the importance of this topic in contemporary practice. This topic is particularly pertinent in today's fast-paced environment, where the demands of modern life can often leads to the neglect of various responsibilities, which can contribute to increased level of insecurity that may ultimately manifest in natural disasters, the occurrence of missing persons, and general emergency events that require the use of these resources.

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1. Introduction

Radio communication plays a crucial role in emergency situations, particularly when conventional communication networks fail. Thanks to their equipment and skills, amateur radio operators often represent the only alternative for communication under such circumstances. According to the International Telecommunication Union (2020), in many parts of the world, radio communication becomes essential when other infrastructures become unavailable. Similar assertions are made by Stewart and Bassett (2023), who, in their manual Emergency Communication 101, note that during natural disasters, the first information reaching rescue services often comes through alternative communication systems, among which amateur radio operators playing a vital role.

Civil protection represents an organized structure intended to safeguard the population, material goods, and the environment in emergencies, including natural disasters, technical-technological accidents, and armed conflicts. In addition to deploying forces and equipment during an emergency, it also encompasses the planning and preparation necessary to address such events effectively (Civilna zaštita, 2025), as recommended by Radio Design Group (2023). An essential component of effective civil protection is the organization of communication systems, with radio links playing a crucial role in establishing and maintaining reliable information connectivity. Amateur radio networks and the Emergency Radio Network (RMZO) contribute significantly to establishing secure and dependable communication during crises, particularly when standard communication systems are compromised.

During natural disasters, initial information received by rescue services often originates from alternative communication channels (Stewart & Bassett, 2023). In emergency situations, regular communication systems often fail (International Telecommunication Union, 2020; Domestic Preparedness, 2023). In such situations, amateur radio systems—due to their self-sufficient and readily deployable nature— often provide essential message transmission services until regular systems are restored. In accordance with their principles and the "Ham Spirit," radio amateurs are encouraged to refrain from engaging in discussions related to politics, religious topics, professional matters, or providing commentary on such topics. In this context, during emergency situations, their role is strictly limited to message transmission.

Given the democratic, civic, and liberal framework of society, amateur radio operators often establish clubs that engage in activities such as participation in the Emergency Radio Network (RMZO). These clubs often provide services to RMZO civil protection units, the armed forces, law enforcement agencies, the Red Cross, and the community at large. In addition to clubs, the legislation on protection and rescue of people and material goods in Bosnia and Herzegovina requires all able-bodied male citizens aged 18 to 60, and women aged 18 to 55, to participate in protection and rescue activities. Furthermore, these regulations permit individuals aged 15 and older to voluntarily participate in civil protection units, engaging in various protection and rescue activities, including the development of emergency communication links.

Participation in RMZO, as well as in protection and rescue operations, is voluntary. Mountain rescue services (GSS) frequently seek the support of amateur radio operators, who, as members of these organizations, assist in setting up communication centers and coordination hubs during rescue operations.

In conclusion, RMZO brings together all the amateur radio operators and technicians who are interested in voluntarily participating in the protection and rescue system, either as independent clubs or as divisions within established radio clubs.

The purpose of this paper is to examine the organization of amateur radio communication systems within the framework of civil protection at the local level, with a particular focus on municipal headquarters in the Federation of Bosnia and Herzegovina.

2. Communication Systems in Civil Protection and the Role of Radio Amateurs through the Emergency Radio Network (RMZO)

All communication systems employed in civil protection activities depend on the support of information and communication technology services. Input data regarding organization and management are collected from the organizations for which connection plans are developed. In the civil protection communication system, the organizational structure is established both vertically and horizontally. Vertically, it corresponds to operational centers at the level of the state, entity, canton and municipal headquarters. Communication is checked at defined time intervals. Through radio communication, the local self-government operational unit communicates with a higher-level operational center, and that level with the Federal Operational Center. At the level of information exchange, communication is conducted using digital communication tools, in real time, with interactive maps.

Communication systems utilized within civil protection can be classified as:

- **Public communication systems** (mobile and landline telephony as well as internet services),
- **Specialized systems** (professional radio networks, emergency medical services, fire and police communication systems),
- **Amateur radio networks** (a voluntary network of operators who provide a backup connection in emergency situations).

Various systems and coverage networks are used to connect operational units and civil protection participants in rescue operations, as well as for their mutual coordination in the implementation of measures and activities of the civil protection system. These systems are notable for their coverage, quality, capacity, and throughput. In emergency situations, public communication systems frequently experience overload or complete failure. Therefore, it is essential to rely on alternative systems, among which amateur radio networks play a crucial role.

Radio amateurs have always proven to be reliable when needed. The amateur radio organizations are the sole civil organizations with exclusive access to their own designated radio frequencies. While these are mostly used for regular activities, amateur radio operators are organized within the **Emergency Radio Network (RMZO)** – an alternative communication system always available to society. According to Allocca (2015), radio amateurs have specific training protocols and communication procedures tailored for crisis situations. They are trained in utilizing digital and voice communication tools to support emergency services. Gibby (2017) further states that amateur radio operators utilize advanced technologies for

encrypted communications and digital protocols, enhancing connectivity in areas with weak signal coverage. Due to their technical skills, autonomous operation from commercial networks, and worldwide connectivity, amateur radio operators represent a vital component of emergency communication systems.

Radio amateurs are often the only ones able to communicate when regular networks are disrupted (International Amateur Radio Union, 2020). Their roles include:

- Establishing emergency communication channels between crisis centers,
- Transmitting messages when other systems are down,
- Coordinating rescue efforts at local, regional, and international levels,
- Providing logistical support to civil protection services.

Radio amateurs operate on different frequency bands, including HF (high frequency), VHF (very high frequency), and UHF (ultra-high frequency), allowing them to cover both local and global communication. In emergency situations that require urgency, radio amateurs follow international procedures and frequencies (International Amateur Radio Union, 2025).

Each country has specialized services equipped and trained to operate in emergencies, from natural disasters to armed conflict. Amateur radio organizations are integrated into this emergency response system due to their key attributes that effectively enhance the efforts of professional services:

- A large number of trained operators positioned strategically across the country, prepared to respond as needed.
- Radio amateurs are particularly adept at operating under improvised conditions, using available equipment, making modifications, and even building missing equipment;

Amateur radio operators are well-trained and experienced in maintaining communication under challenging conditions, such as low signal strength and interference.

- Amateur radio equipment is widespread and technically versatile for various purposes;
- Amateur radio stations are highly portable and can be efficiently deployed as mobile units in various locations;
- The Emergency Radio Network (RMZO) is a system that can be rapidly deployed and activated to facilitate information transfer.

The objective of the RMZO is to establish and sustain an autonomous radio communication network that is independent of terrestrial and satellite infrastructure. This network is intended to be activated during significant emergencies or disasters until normal communication channels can be reestablished.

The primary function of the RMZO is to facilitate the transmission of data, email, and voice messages both locally and internationally, particularly in situations where alternative communication methods are unavailable.

The equipment utilized within the RMZO typically consists of either club-owned or personally provided gear supplied by radio amateurs for emergency operations. This encompasses fixed, mobile, and handheld radio stations operating on HF, VHF, or UHF frequencies, as well as power sources including generators, batteries, and accumulators. Additionally, it includes antennas, modems, and interface devices.

Key characteristics and specific features of the RMZO include:

- **Compatibility** – Communication between amateur and professional radio systems is possible;
- **Interoperability** – It is possible to coordinate and communicate with other protection and rescue systems within Bosnia and Herzegovina, Europe, and globally as needed;
- **Flexibility** – A significant number of radio stations eliminate vulnerable nodes, and in the case of a failure, communication can be rerouted through other channels and frequency bands.
- **Modularity** – Can be used ad hoc as a standalone module or integrated into existing systems;
- **Cost-effectiveness** – The equipment is already available and can be incorporated into operational requirements without incurring additional costs.

RMZO operates according to national regulations and international protocols (IARU – International Amateur Radio Union), enabling effective coordination among different countries and organizations. Systematic planning and implementation of emergency communication (EMCOMM) structures are essential for communication sustainability in emergencies (Blokdyk, 2020). Radio amateurs working through RMZO often collaborate with official government agencies to ensure continuous communication during crises. The IARU offers guidelines for amateur radio operators on how to provide assistance during emergency situations, including designated frequencies and technical protocols. In Bosnia and Herzegovina, the RMZO system operates through entity-level organizational structures (Parliamentary Assembly of Bosnia and Herzegovina, 2003).

Activating the RMZO involves defining the notification process at the local level. A command station is established, and one or more operators designated to communicate information to the relevant units. Members must already be part of a predefined group and activated under the supervision of a civil protection officer or liaison officer. If the first liaison officer is unavailable, the second on the list is contacted. Communication channels for notifying RMZO volunteers may include telephone, SMS, email, or pre-agreed frequencies.

It is essential to adhere to international procedures and frequencies reserved for emergency situations. According to Van De Walle, Turoff and Hiltz (2010), effective communication with emergency services can save lives, and radio amateurs play a crucial role in maintaining these connections. The International Amateur Radio Union (IARU) (2025) provides

basic guidelines for amateur radio operations in crises. In theory, and as practice shows, training protocols and communication are essential components of an effective emergency response, as outlined in the Fele (2023) handbook, which focuses on organizing calls to emergency centers. The frequencies on which RMZO operates are defined according to the IARU for each region as communication frequencies for emergencies, with deviations of +/- 20kHz. In this case, some IARU members may retain these frequencies and request their release in case of emergency or member states may set their own frequencies, considering the frequencies of local services and possible interference from radio broadcasts or other forms of interference from other radio stations. Some countries have allowed public disclosure of frequencies for their emergencies, including Bosnia and Herzegovina.

Radio amateurs use various technical resources and infrastructure, including portable devices and power systems that are independent of main power grids, as accurately noted by Barić, T., & Glavaš, H. (2024). Gibby (2017) provides a detailed guide on different types of communication used by radio amateurs, including digital and voice technologies. Additionally, Allocca (2015) in his guide notes that many radio amateurs use autonomous power supplies to ensure stable communications in emergency circumstances. Amateur radio operators trained for EMCOMM use both analog and digital methods for real-time message transmission (Gibby, 2017). Amateur radio networks use various technologies to establish and maintain communication in crisis situations, including:

- Analog and digital radio stations – FM, SSB, DMR, D-STAR, C4FM
- Automatic repeaters – Extend the range of VHF/UHF communications
- Packet radio (APRS, Winlink) – Transmission of digital data over the radio network
- NVIS antennas – For medium-range shortwave communication
- Solar and battery-powered systems – Provide autonomy during power outages

To ensure efficiency, RMZO networks rely on predefined procedures, which include:

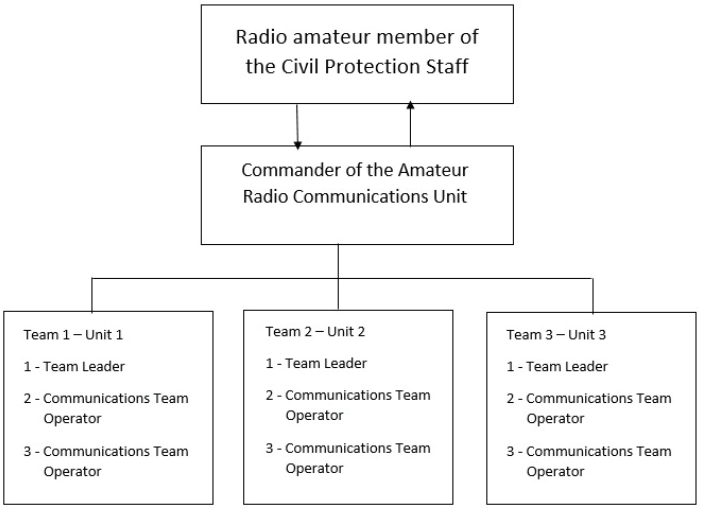
1. Network activation – Defined protocols for activation in case of an emergency,
2. Use of coded messages – Standardized formats for transmitting emergency information,
3. Command hierarchy – Central control points coordinate the work of operators.
4. Testing and training – Regular drills to check operational preparedness.

3. Organization of the Amateur Radio Unit of the Civil Protection Municipal Staff of Novo Sarajevo

The Amateur Radio Service (hereinafter referred to as the Service) in its regular activities of maintaining amateur radio connections adheres to the rules of 92/2020 of the Communications Regulatory Agency of Bosnia and Herzegovina, the recommendations and

procedures from the HF Manual of the International Amateur Radio Union, version 9 from 2018, and the recommendations and procedures from the VHF Manual of the International Amateur Radio Union, version 9.01 from 2021. As part of its regular activities, the Service participates in the preparation and implementation of protection and rescue operations. The primary purpose of the Service is to organize and establish communication within the parent protection and rescue service and its affiliated units, using amateur radio frequencies for message transmission during an emergency situation until standard telecommunication channels are reestablished. Members of the unit engaged during the operation enjoy the status of members of the Civil Protection unit and have all the rights under the Law on Protection and Rescue of People, Material Goods, and Other Disasters of the Federation of Bosnia and Herzegovina. In their work during emergencies, the service follows the International Emergency Operation Procedure IARU HF and the internal procedures of the Service.

The Service is composed of three units, each comprising a minimum of three members, including a designated leader or commander for each unit, as well as a head of the Service. The unit members are volunteer amateur radio operators from a radio club that has a special cooperation agreement with the municipal Civil Protection Staff.



The service manager is responsible for establishing the administrative station. Efficient organization of calls and responses is essential for operational efficiency during emergency situations, as evidenced by numerous analyses of EMCOMM systems (Fele, 2023). In the event of an emergency, the first operator from any unit who arrives first at the frequency assumes the role of the administrative station until the head of the service arrives and the administrative station is established. In emergencies, a directive network system is established, where the administrative station controls all activities. In case of high activity on the frequency, the administrative station, along with its units, can form a subnet.

Amateur radio operators adhere to established training protocols and communication procedures designed for crisis situations (Allocca, 2015). The head of the service holds a supervisory position over the units and their members, establishing direct communication

and command relationships with the staff member responsible for the service within the Municipal Civil Protection Headquarters. He ensures that there is always an adequate number of operators for each shift, as well as for network supervision and broadcasting conditions. If multiple communication networks are established under the service's umbrella, the head of the service is responsible for coordinating the entire service network. It is important to note that the Service operates under the directives of the Municipal Civil Protection Headquarters. It can also fulfill orders from other authorities when explicitly authorized by the relevant civil protection headquarters if the competent civil protection headquarters so prescribes by a special decision or if an order is issued during an emergency.

On the other hand, service members are not authorized to perform duties of the other services, except for activities related to communications via amateur radio, security-related tasks, or situations involving potential threats to life and body. During their regular activities as preparation for emergency situations, the service conducts testing and equipment range verification exercises at least twice a year. As part of its routine emergency preparedness activities, the Service at least twice a year conducts exercises to evaluate and confirm the functionality and range of radio communication equipment.

In the event of an emergency or mobilization of the service for participation in protection and rescue efforts, the head of the service will assign tasks to the units, deploy the units, and establish a duty system in coordination with the operational center. Members of the units engaged in the work tasks must ensure uninterrupted signal transmission and reception using the designated transmission equipment.

In emergency situations, unit members are required to communicate in their native language. For clarity, messages are, when necessary, spelled out using the phonetic alphabet commonly adopted in international amateur radio communications. It is the responsibility of the unit members and service personnel to communicate the necessary information during emergency situations until standard communication channels are restored.

4.Types of Radio Networks in Case of an Emergency Situation

In the event of an emergency, various networks may be established at the municipal civil protection headquarters to effectively carry out their respective functions. These networks may include:

a) **Traffic Network** – responsible for the transmission of written messages between the locations of professional services or between multiple activated networks;

b) **Resource Network** – a network established to facilitate the receipt of additional instructions, identify required equipment, and register new operators;

c) **Tactical Network** – used for forwarding local messages at the site of the emergency situation, facilitates communication between various emergency services, transmits monitoring messages and reports on river levels, fire spread, rescue operations, property, finding dead bodies, and similar situations;

d) **Informational Network** – facilitates regular notifications, announcements, and dissemination of information on various matters;

e) **Health and Social Network** – provides information between interested parties outside the area affected by the emergency situation and the use of the civil protection services.

Amateur radio networks are integrated into international emergency communication systems, with the IARU organizing global RMZO activities and ensuring compliance with international standards. Furthermore, in the case of large-scale disasters, amateur radio operators often cooperate with organizations such as the ITU, UN, and the Red Cross. In Bosnia and Herzegovina, RMZO operates under the auspices of three amateur radio associations and complies with the rules set by the Communications Regulatory Agency (RAK BiH). Similar legal frameworks exist in the other region's countries and they frequently utilize guidelines established by the International Telecommunication Union (ITU).

5.Practical Examples

Amateur radio operators play a key role in maintaining communications during disasters (ARRL, 2015). To understand the importance of RMZO in real-world conditions, there have been successful collaborations between amateur radio operators and state authorities, with radio amateurs providing their services (International Amateur Radio Union, 2020; Domestic Preparedness, 2023). Here are a few examples where amateur radio operators played a critical role when conventional systems failed.

During the catastrophic floods in Bosnia and Herzegovina, amateur radio operators organized emergency communications between crisis centers in Sarajevo, Banja Luka, Tuzla, and Bijeljina. Many parts of the country were without electricity and mobile phone service, but amateur radio operators, using mobile antennas and HF and VHF radio equipment, enabled the coordination of rescue teams.

On the international stage, following a devastating earthquake, amateur radio operators from the Croatian Amateur Radio Network for Emergencies (HRS RMZO) quickly activated their stations and established communication between the affected areas and the crisis headquarters in Zagreb. The APRS system was used to send digital messages when mobile networks were overloaded.

In the United States, amateur radio operators from the ARRL ARES network (Amateur Radio Emergency Service) assumed a vital communication role during the evacuation and rescue of thousands of individuals when all other communication channels were rendered inoperative. It is important to recognize that amateur radio operators in the United States play a significant role in emergency response and communication efforts.

These examples illustrate the essential role of RMZO in situations where conventional systems are unable to operate effectively.

6.Technical Upgrades of RMZO through Digital Technologies

Modern technological development allows RMZO networks to be not only voice-based but also digital and automated. Cid et al. (2017) in their study explore innovations in amateur radio communication that support medical assistance during large-scale disasters and emphasize the importance of using innovations in communication technologies to support emergency medical situations. Some of the advanced systems currently used in RMZO include:

- **Winlink Global Email System** via radio communication, which enables sending emails without internet infrastructure. Winlink can operate solely through radio communication, using HF PACTOR, VARA, or ARDOP modems, allowing the sending of emails via the shortwave spectrum (3.5 MHz, 7 MHz, 14 MHz). VHF/UHF RMS Gateway stations allow local radio communication to be used instead of the internet, if an operational Winlink node exists in the crisis area. If the RMZO team can set up a temporary Winlink RMS node, it will enable the local transmission of email messages to the first functional node outside the emergency zone.
- **DMR and D-STAR Digital Radio Systems**, which deliver reliable audio signals over extended distances and can operate independently in a "local-only" mode without the need for internet connectivity. They operate in simplex mode utilizing portable repeaters. Cross-band connections with analog systems are also possible, as some digital repeaters allow cross-band connections with analog VHF/UHF stations, thereby extending the range and connecting more RMZO operators.
- **APRS (Automatic Packet Reporting System)**, is utilized for transmitting location data, weather information, and text messages via radio communication and can operate without the internet using radio transmission exclusively between mobile and handheld radio stations over VHF frequencies.
- **Integration with IoT Sensors**, used in advanced RMZO for monitoring of floods, fires, and earthquakes.

Regarding power supply, the dominant technology employed in emergency situations are generators and solar panels used for battery recharging. Therefore, amateur radio stations use their own power sources (Ham Radio Prep, 2025).

7.Conclusion

Reliable communication is a key factor in successfully responding to crisis situations. To respond more effectively to emergency situations, it is necessary to improve the regulatory framework and training for amateur radio operations. Blokdyk (2020) emphasizes that it is crucial for amateur radio operators to be adequately trained and for operational protocols to be clearly defined in order to ensure the optimal functionality of emergency communication systems. Amateur radio networks, including RMZO, represent an indispensable segment of the civil protection system, providing independent, secure, and adaptable communication capabilities. Their technical infrastructure, operational preparedness, and global connectivity position them as one of the most secure communication solutions available for emergency situations. This paper highlighted the successful organization of a local-level unit in Bosnia and Herzegovina, specifically the amateur radio unit within the Novo Sarajevo municipal civil protection headquarters. Radio networks for emergencies (RMZO) are a key component of the civil protection system, offering alternative and autonomous communication pathways in situations where standard systems are disrupted. Thanks to technological innovations, the inclusion of digital technologies, and international cooperation, RMZO networks are evolving into more effective tools for crisis communication. In the future, further development of digital

platforms and automated systems can further enhance the operational efficiency of RMZO and make them even more significant in the global emergency communication system.

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